STRATOSPHERIC OZONE TRANSBOUNDARY TRANSPORT TO UPPER TROPOSPHERE NORTH AFRICA

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1. INTRODUCTION

Stratosphere-troposphere exchange (STE) influences the chemical composition of both the stratosphere and the troposphere and represents an important aspect of global change [Butchart and Scaife, 2001]. It is also often associated with severe weather events [Goering et al., 2001]. Upper tropospheric ozone is an important greenhouse gas that affects global outgoing long wave radiations, chemistry, climate, and the radiation budget [Holton et al. 1995]. Their changes have a great impact on the surface temperature [Forster and Shine, 1997].

The Measurements of Ozone by Airbus In service airCraft (MOZAIC) program was designed to collect ozone and water vapor data using automatic equipment installed on board five long-range Airbus A340 aircraft flying regularly all over the world [Marenco et al., 1998]. The overall objective of the programme is to improve our physical and chemical understanding of the atmosphere. According to Danielsen [1982] air in the stratosphere has high static stability and, as a result, high IPV values greater than 1.5 IPV units (1.5 X 10^{-6} K kg^{-1} m $2s^{-1}$) are typically found only in the stratosphere; thus IPV can also be used to trace ozone-rich air which has moved from the stratosphere to the troposphere. This work will identify the causes and sources of MOZAIC ozone enhancements at upper tropospheric North Africa (20-35^0 N). In addition the paper will address the modes of transport of ozone rich airmass sampled by MOZAIC at mid latitude and North Africa.

2. DATA AND METHOD

We have used for the present case study, ozone data from MOZAIC. Cruise enhanced ozone measurements sampled on the flight route between Johannesburg to Vienna over North Africa and mid-latitude regions are investigated. Along the flight route, high ozone peak at North Africa (20-30^0 N) and mid latitude region (30-48^0 N) were observed at a flying altitude of about 250-200 hPa (Fig.1 rectangular box).

For diagnostic purpose additional data sets such as ozone mass mixing ratio, potential vorticity on a pressure level PV and on isentropic surface (IPV), zonal (U) and Meridonal (V) wind fields at pressure and potential temperature levels derived from ECMWF-ERA interim Re-analysis [ECMWF, 2010] at different potential temperature and pressure levels were used.

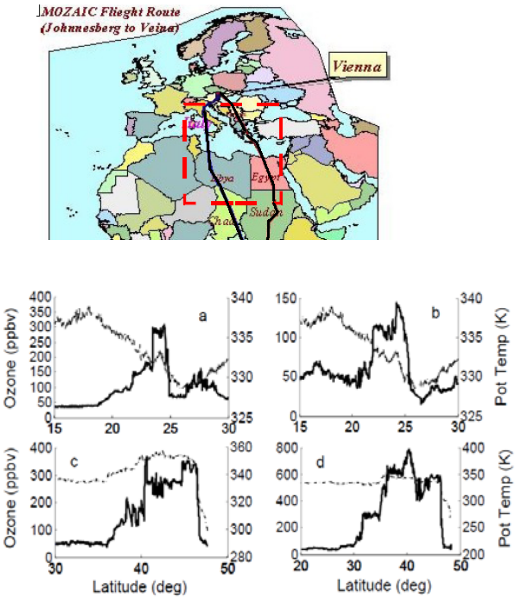

FIG.1. Segment of most frequent MOZAIC flight routes (upper Panel) and enhanced ozone observation (lower panel). The dotted lines represent potential temperature along the flight route.

3. RESULTS AND DISCUSSION

Ozone is indicated by solid line in the lower panel Fig.1. The dashed line shows potential temperature along the flight route which is calculated from MOZAIC temperature record. The first case is depicted in Fig.1 (panels a and b) are characterized by enhancements with in African latitude and produced, including the case shown in panel c, with similar events. On the other hand, the panel d depicts an enhancements outside the African boundary (> 35.5° N) and produced with a different event. In this section, the source of ozone enhancements over mid-latitude and North Africa and the mode of ozone transport for the observed two cases are discussed.

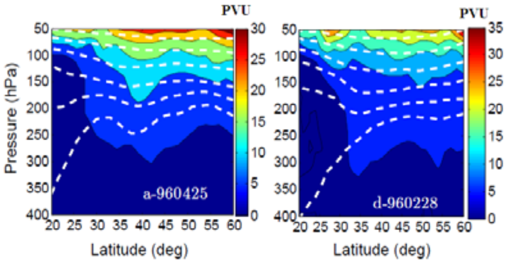

FIG.2. Meridional cross-section on potential vorticity at 1.5 E on 25 April 1996 (a)and at 13.5 E for 28 February 1996(d) 00 UTC. The white dashed lines are isentropic lines at 330, 350, 370, 395, 430 and 475 K levels.

In all cases of enhanced MOZAIC ozone observations, Fig. 2, the VMR is greater than 100 ppbv. A separate relative humidity measurement simultaneously with ozone by MOZAIC in the region of ozone enhancement (not shown) is less than 25%. Negative correlation of these two quantities at flight level (200 hPa) indicates the air mass sampled by MOZAIC is from stratospheric origin.

FIG.2(a and b) and FIG.3 (a-d) illustrate modes of air mass transport across or along isentropic surfaces. Across isentropic surface air mass transport is observed for 25 April 1996. Ozone enhancement shown in Fig.1a is likely due to ozone rich air mass ejected obliquely through the PV- tongue at 100 hPa and 35^0 N.

The second case is along isentropic surface air mass transport, for Feb. 28, 1996. Almost parallel isentropic lines shown in FIG.2d (white-doted lines) as well as the PV orientation shows along isentropic transport. Secondly, high IPV at the polar vortex which decreases all the way to 30^0 N also confirms a dominant along isentropic surfaces transport (FIG 3d). This brings along isentropic transported enhanced stratospheric ozone to upper troposphere mid-latitude and North Africa (FIG 2b).

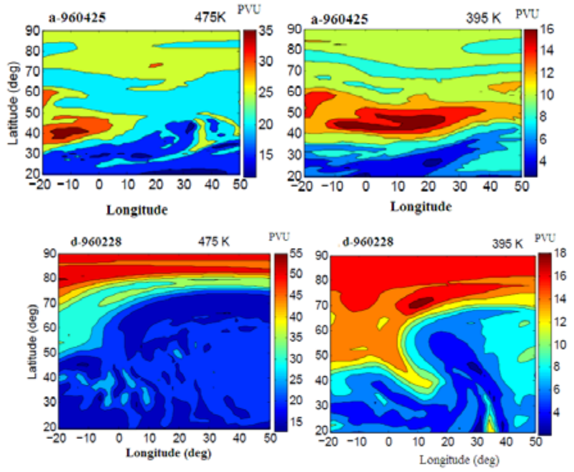

FIG.3. Potential Vorticity on 475, 395 and 350 K isentropic surfaces for April 25, 1996 (upper panels) February 28, 1996(lower panels) respectively.

These observations clearly show that polar and mid-latitude are intense STE regions. Enhanced stratospheric ozone transported from these regions to upper troposphere North Africa. This would have a significant effect on chemistry, climate and radiative forcing.

4. REFERENCES

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